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(54) Title: ELEVATING NUTRIENT-RICH OCEAN WATER


(57) Abstract

Nutrient-rich water from the aphotic zone of the ocean, which normally begins at about 100 to 200 meters below the ocean surface, is desalinated or partially desalinated *in situ* using electro-dialysis means (12) while leaving the nutrients in the water. The nutrient-rich desalinated water thus obtained, being of lesser density than the surrounding seawater, naturally rises through conduit (20) into the relatively nutrient-poor photic zone of the ocean and is dispersed therein, thus increasing the concentration of nutrients in the photic zone near the surface of the ocean. This increases the fertility of the near-surface photic zone, and thus increases the supply of harvestable food fish from the near-surface photic zone.


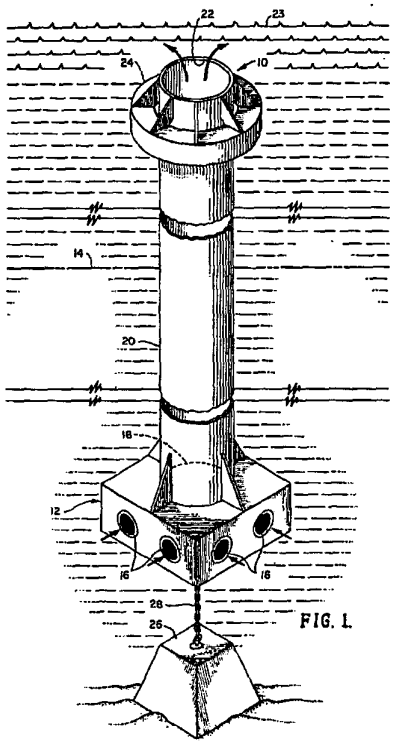


FIG. 1.

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# ELEVATING NUTRIENT-RICH OCEAN WATER

## Technical Field

The present invention relates to increasing the amount of organic nutrients in ocean water, particularly within a few hundred feet of the surface, so as to increase the production of harvestable food in these near-surface waters. Specifically, this invention concerns itself with a means for artificially inducing an upwelling of relatively nutrient-rich water from the lower depths of the ocean into the relatively nutrient-deficient near-surface waters.

## Background Art

Life on earth depends ultimately on food created by green plant organisms through the process known as photosynthesis. Photosynthesis requires the presence of sunlight, and, in the oceans, sufficient sunlight to support the process of photosynthesis is present only in the water that is less than 100 to 200 meters below the surface. This area where all the ocean's photosynthesis takes place is known as the photic zone. Below the photic zone is the area where there is insufficient light to support photosynthesis, and this zone is known as the aphotic zone.

Because of the presence of sunlight for photosynthesis, the photic zone is the habitat for the minute green plant organisms known as phytoplankton which comprise the first link in the food chain which culminates in those organisms which are consumed as food by man. However, the amount of life which can be sustained in the photic zone is limited by the quantity of such substances as nitrogen, phosphorous, copper, and organic nutrients, which are required to sustain life. In the photic zone these

substances are constantly being depleted by the life forms present in the zone and thus the amount of life which the photic zone can support is self-limiting.

However, the above-mentioned life sustaining substances and nutrients are present in constant abundance in the aphotic zone below the photic zone. This is due to the relative scarcity of nutrient-depleting life forms in the aphotic zone. Furthermore, the aphotic zone is constantly enriched in nutrients from decaying organic matter that sinks from the overlying photic zone. Thus, the aphotic zone is, on the average, substantially richer in nutrients than the photic zone.

Therefore, if nutrient-rich water from the aphotic zone can be introduced into the photic zone, the amount of life that could be sustained in the photic zone would be substantially increased. Such a mixing of aphotic zone water and photic zone water is not easily achieved since the aphotic zone water is normally colder and thus denser than the photic zone water and will therefore not normally rise into, and mix with, the photic zone water. However, in a number of areas in the ocean, a variety of natural mechanisms serve to bring the deep aphotic zone water up into the photic zone. These areas are known as "upwelling areas" and they occur in places where offshore winds, equatorial currents, or large ocean waves are strong enough to produce a substantial mixing and churning effect that is sufficient to pull the deep water into the near-surface photic zone. Also, in polar seas, seasonal cooling of the surface water causes the surface water to become cooler and denser than the deeper water and thus an upwelling situation can arise in such areas. Because of the upwelling of nutrient-rich aphotic zone water into the photic zone, these upwelling areas are extraordinarily fertile, and it has been estimated that these upwelling areas support approximately one-half

of the total available food fish in the oceans, even though these upwelling areas constitute only a small fraction of the total sea surface.

As the state of the art exists today, there is no practical means for inducing upwelling by means of artificially induced thermal convection currents.

## Summary of the Invention

The present invention avoids the disadvantages of thermally operated systems through the use of a radically different principle for moving the deep water upward. Seawater, with its substantial quantity of solutes, is significantly denser than fresh water. Therefore, if a portion of the solutes are removed from the deep aphotic zone water, it becomes less dense than the surrounding water and rises into the photic zone where it disperses. The present invention makes use of this principle by submerging a water desalination device well below the boundary between the photic and aphotic zones. The desalination device may operate, for example, by means of electro-dialysis, such devices being well known in the art of water desalination. Any desalination device which substantially reduces salt content while leaving the water nutrient-rich could be used. Known electro-dialysis processes leave a high concentration of nutrients in the dilute portion of the water because they cannot pass through the membranes, while the salt ions are pulled through the membranes by electric forces.

Preferably the device does not require any source of power from the surface, such as electrolytic desalinators of a known type which are operated by the temperature differential in the water. For desalinators requiring power from the surface, power lines would be extended down to the device. In any event, deep aphotic zone water enters the desalination device and is partially desalinated therein. The partially desalinated water so produced still contains a substantial quantity of nutrient

substances. It is believed that a reduction of about 20% of the salinity might achieve satisfactory results while leaving sufficient nutrients. This partially desalinated water, being less dense than the surrounding seawater, rises naturally upward through conduits into the photic zone where it is dispersed into the surrounding water, thereby fertilizing the photic zone water with the fresh nutrients from the deep aphotic zone.

## Brief Description of the Drawing

Figure 1 is a perspective view of the present invention showing it in its under-sea implacement.

## Detailed Description of the Invention

The present invention, designated generally in the drawing by the numeral 10, consists of a seawater desalination unit 12 which is submerged in the ocean in the aphotic zone which, in the drawing, is the area below the dotted line 14. Seawater from the aphotic zone flows through intake ports 16 into the desalination device where the water is partially desalinated, for example, by means of electrolysis. The partially desalinated water leaves the desalination device through outlet port 18 from which, due to its decreased density as compared to the surrounding water, it rises through a conduit 20 which guides the water up into the photic zone (the area above the dotted line 14) near the ocean surface 23 where it is dispersed through the dispersal outlet 22.

The entire device may be suspended in the ocean's depths by means of gas-filled buoyancy tanks 24 in conjunction with an anchor 26 and anchor chain 28. Alternatively, the device may be suspended from cables attached to surface buoys. Various other means may be devised to suspend the device at the desired depth without departing from the concept of the present invention.

CLAIMS

1. A method of bringing nutrient-rich ocean water from the aphotic zone of the ocean up to the photic zone to increase the concentration of nutrients in the photic zone, comprising:

submerging a water desalinating means into the aphotic zone of the ocean;

introducing seawater from the aphotic zone into desalination means;

at least partially desalinating the seawater introduced into said desalinating means while leaving a high concentration of nutrients in said desalinated seawater; and

conducting the desalinated water thereby produced into the photic zone of the ocean.

2. A method, as defined in Claim 1, and further comprising the steps of dispersing the nutrient-rich desalinated water in the photic zone.

3. A method, as defined in Claim 1, wherein said desalination is done by electro-dialysis.

4. An apparatus for bringing relatively nutrient-rich ocean water from the aphotic zone of the ocean up to the relatively nutrient-poor photic zone, comprising:

a seawater desalinating means submerged into the aphotic zone;

said desalinating means producing at least partially desalinated water from the seawater introduced thereinto while leaving said desalinated seawater relatively nutrient-rich; and

a conduit for conducting said nutrient-rich desalinated water from said desalinating means to the photic zone of the ocean, primarily through the use of the density differential between the desalinated water and the seawater.

5. An apparatus, as defined in Claim 4, wherein said desalinating means functions primarily through the process of electro-dialysis.

AMENDED CLAIMS
(received by the International Bureau on 17 January 1979 (17.01.79))

1. A method of increasing the concentration of nutrients in the water of the photic zone of the ocean, comprising the steps of:

submerging a water desalinating means into the aphotic zone of the ocean;

introducing nutrient-rich seawater from the aphotic zone into said desalinating means;

partially desalinating the seawater introduced into said desalinating means so that the partially desalinated seawater retains a substantially higher concentration of nutrients than the water in the photic zone, while becoming significantly less dense than the water in the aphotic zone;

conducting said partially desalinated seawater into the photic zone primarily through the use of the density differential between said partially desalinated water and seawater; and

substantially increasing the concentration of nutrients in the photic zone by dispersing said partially desalinated, nutrient-rich water into the water of the photic zone.

2. The method of Claim 1, wherein said partial desalination is done by electro-dialysis.

3. An apparatus for substantially enriching the photic zone of the ocean with nutrient-rich water from the aphotic zone, comprising:

desalinating means, submerged into the nutrient-rich aphotic zone of the ocean, for producing partially desalinated water that is significantly less dense than the seawater in the ocean, while retaining a substantially greater concentration of nutrients than the water in the photic zone; and

means for (a) conducting said partially desalinated water from said desalinating means to the photic zone primarily by means of the density differential between said partially desalinated water and the seawater in the

ocean, and (b) dispersing said partially desalinated water into the water in said photic zone to increase substantially the concentration of nutrients therein.

4. The apparatus of Claim 3, wherein said desalinating means uses the process of dialysis.

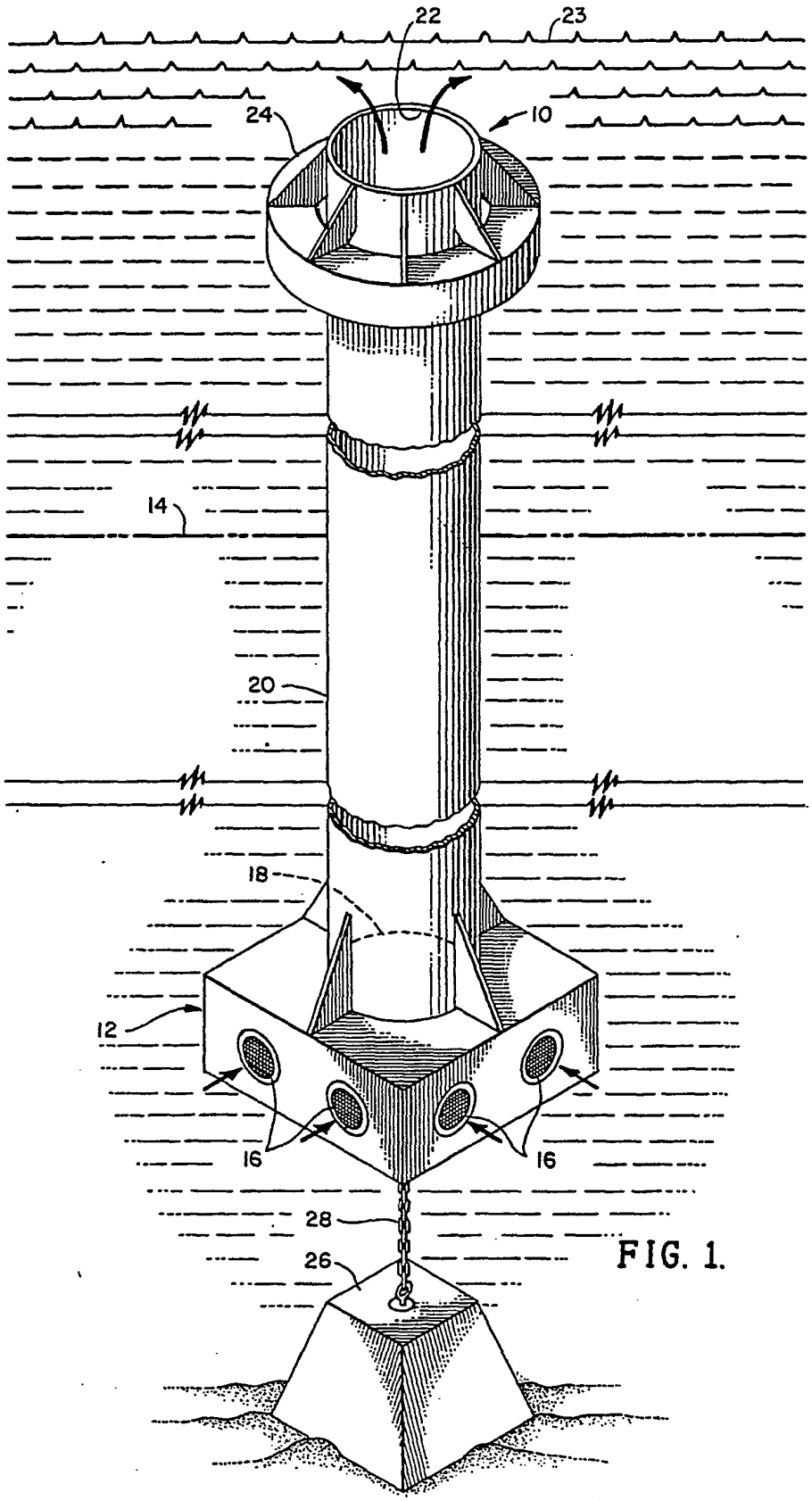


FIG. 1.

# INTERNATIONAL SEARCH REPORT 79/00150

International Application No PCT/US78/00067

## I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

INT. CL. B01D 13/00, 13/02, 31/00, 31/02; C02I/82

U.S. CL. 210/23H, 170, 321R, 433M, 204/180P, 301

## II. FIELDS SEARCHED

**Minimum Documentation Searched [4]**

| Classification System | Classification Symbols |
|---|---|
| U.S. | 210/22, 23H, 170, 321R, 433M; 204/180P, 301 |

**Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]**

## III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

| Category [6] | Citation of Document, [16] with indication, where appropriate, of the relevant passages [17] | Relevant to Claim No. [18] |
|---|---|---|
| X | N, SCIENCE, ISSUED 18 JANUARY 1974, OCTAVE LEVENSPIEL ET AL, THE OSMOTIC PUMP, VOLUME 183, NUMBER 4121, PAGES 157-160. | 1-5 |
| X | N, FILTRATION AND SEPARATION, ISSUED NOVEMBER 1971, BRIAN LEIGHTELL, RO - HOW IT WORKS, WHAT IT COSTS, PAGES 715-717. | 1-5 |
| X | US, A, 3,283,813, PUBLISHED 8 NOVEMBER 1966, E.R. BROWNSCOMBE ET AL. | 3,5 |
| A | US, A, 3,456,802, PUBLISHED 22 JULY 1969, M. COLE. | 1,4 |
| A | US, A, 3,171,808, PUBLISHED 2 MARCH 1965, H.W. TODD. | 1,4 |
| X | N, THE CHEMICAL ENGINEER, ISSUED JANUARY 1972, J.R. GROVER ET AL, OPERATING EXPERIENCE WITH A 23 $M^3$/DAY REVERSE OSMOSIS PILOT PLANT, PAGES 24-28 | 1-5 |

* Special categories of cited documents: [15]

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"X" document of particular relevance

## IV. CERTIFICATION

| Date of the Actual Completion of the International Search [2] | Date of Mailing of this International Search Report [2] |
|---|---|
| 10 OCTOBER 1978 | 14 December 1978 |
| **International Searching Authority [1]** | **Signature of Authorized Officer [20]** |
| ISA/US | DAVID R. SADOWSKI |